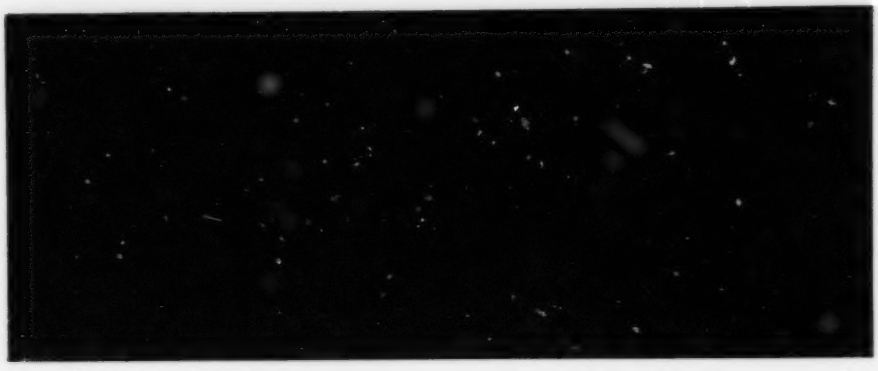
Saskatchewan
Agriculture
and Food

# Agriculture Development Fund



91-02572/

Final Report

R-86-01-0148

# Evaluation of Farrowing Systems

Conducted by G. Christison
J. de Gooijer, C. Rhodes and I. Wenger

Funded by the Agriculture Development Fund

ADF FINAL REPORT, DECEMBER 1989

R-86-01-0148

# EVALUATION OF FARROWING SYSTEMS

## Executive Summary

Four sub-projects were performed and are described separately.

As reported in September 1988, there were problems in the sub-project on the use of a heat lamp controller by pigs because the pigs learned slowly. Researchers at the University of Guelph had been successful in training small groups of newly weaned pigs to operate similar controllers. However, the Guelph researchers have subsequently been unable to train groups of ten pigs. In our trials we attempted to train whole litters to use a controller while the sow was still present. Based on the Guelph experience, and with their advice, the sub-project was discontinued.

The sub-project on the use of creep areas by piglets is complete. There were no practical differences among the various pen layouts in the amount of time piglets spent in dangerous regions near the sow. An abstract, summary and technical report (#1) are provided separately.

The sub-project on the health and performance of piglets and sows in pens of various designs is complete. None of the three farrowing crates had any effect, but one of the floor types increased the foot and leg injuries of newborn piglets. An abstract, summary and technical report (#2) are provided separately.

The sub-project on giving pigs supplemental milk at birth is complete. A single dose of milk replacer at birth did not affect piglet survival, teat seeking success, immunoglobulin status, or ability to tolerate cold. An abstract, summary and technical report (#3) are provided separately.

## List of Papers Prepared and Talks Given

G.I. Christison and I.I. Wenger. Nutritional Supplements for Newborn Pigs - a Help or a Hindrance? Swine Nutrition Conference, Saskatoon, May, 1989

G.I. Christison. Interviewed by Canadian Press concerning pen design for an article distributed nation wide, May, 1989

I.I. Wenger and G.I. Christison. Effects of Dosing with Milk Replacer on Teat-seeking Behavior, Growth and Survival of Newborn Piglets. Canadian Society of Animal Science Annual Meeting, Montreal, July, 1989

G.I. Christison. Floors for Sows and Pigs. NPD Producer Meeting, Saskatoon, October, 1989

D.A. Francis. What Sows and Young Pigs Can Tell us About Floors. Ontario Pork Industry Improvement Plan Seminars. Several cities, February, 1990

I.I. Wenger. Master's Thesis concerning supplemental feeding of newborn pigs expected in March, 1990. An abstract has been prepared for presentation at the International Pig Veterinary Congress, Switzerland, July, 1990.

Technical reports similar to those included here will be published in the Prairie Swine Center Annual Report, 1990. This is widely distributed among provincial swine producers and appropriate specialists.

Four scientific papers are expected to arise from the work reported here.

Expenditures

A verified statement of expenditures will follow as soon as it becomes available.

Personnel, and Percentage of Their Time Involved Since March 1, 1989

| | |
|---|---|
| G.I. Christison, Professor | 10% |
| I.I. Wenger, Graduate student | 60% |
| J.A. de Gooijer, Technician | 60% |
| D. Crawford, Technical assistant | 100% |
| V.J. Wiemken, Technician | 100% |
| J.J. Olver, Summer student | 100% |
| C.A. Elian, Technician | 50% |
| Several stockmen, total | 10% |

Note that some of these people worked for only a few months.

Equipment Purchased of Value in Excess of $500

None

Abstract and Summary #1, R86-01-0148

# FARROWING CRATE DANGER ZONES

G.I. Christison and J.A. de Gooijer

## ABSTRACT

Modern day farrowing pens can be divided into what are considered "danger" zones and "safe" or creep areas. A relatively large percentage of piglets die in the first few days post-farrowing. The percentage of time piglets spend in these areas and how it affects mortality was studied. The five crate/pen designs were: Straight-no front creep, Straight-with front creep, Converta-pen, Angle-no front creep and Angle-with front creep. Danger zone usage was unaffected by pen design but it was greatly influenced by time since farrowing. Safe area usage showed significant daily increases from day 1 to day 3. Piglets spent significantly more time in the nursing position in the straight-with front creep pens than the others. Careful observation and intervention on the part of the producer during the time period immediately post-farrowing may help reduce pre-weaning mortality.

## SUMMARY

Despite the developments in modern day farrowing systems a relatively large percentage of newborn piglets die during the first few days post-partum due to starvation and crushing. The farrowing pen can be divided into safe "creep" areas and high risk "danger" zones near the sow where the weak piglets are liable to be crushed. The objectives of the project were to evaluate the amount of time piglets spend in the danger zones and in the creep areas within the first three days after birth and to relate these to piglet mortality.

Twenty-five purebred sows were randomly assigned to one of the five pen designs. Sow and piglet behavior and performance were evaluated. The five pen designs were 1) Straight-no front creep 2) Straight-with front creep 3) Converta-pen 4) Angle-no front creep and 5) Angle-with front creep. All of the crates with the exception of the Converta-pen were KG Johnson and all pen floors were plastic-coated expanded metal (Tenderfoot). The pens measured aproximately 1.5 m x 2.47 m including the creep areas.

Floors were marked with a grid outlining six distinct areas, labelled A to F. Zones A,B & C were directly underneath the sow, D and E were adjacent to the sow's udder and F was the front creep area regardless of lamp location. ABC are considered to be danger zones while DEF are considered to be safe zones for the piglets. Any area of the pen floor which is not included in the zones ABC, DEF or Nurse is referred to as "Other". In the straight pens with front creeps both heat lamps were moved from beside the sow to the front creep area 24 hours after farrowing. In the angle pens with front creeps only one lamp could be moved. Only two of the five pen types had front creep areas (F).

Time lapse video cameras were used to monitor creep area usage on a continuous basis for the first 3 days. Piglets were weighed, dried and numbered at birth and returned to the sow within 2 minutes. Sow and piglet movements and behavior were recorded on a continuous basis during the farrowing process (Period 1). Period 2 lasted for 4 hours after the last piglet born had been returned to the sow. Periods 3 and 4 occurred in the morning and afternoon on Day 2 and Periods 5 and 6 on Day 3. Periods 3 to 6 were 2.5 hours in length. Period one (during farrowing) was too variable so it was eliminated from the analysis. Data was collected daily on piglet weight gain, injuries and treatments.

Piglet behavior in the danger zones was greatly affected by the time period. Piglets spent significantly more time in dander zones during Period 2 than any other time period. This was due to the piglets spending the majority of their time nursing so when the sow stood up the piglets moved (fell) into this zone. Because there were no heat lamps, piglets spent significantly less time in the front creeps during the first day than in subsequent days. There were significant daily increases in creep area use on day 2 and day 3. The straight pens attracted a significantly higher percentage of piglets to the front creeps than the angle pens. Piglets spent significantly more time during Period 2 nursing or sleeping in the nursing position. The amount of time nursing decreased on day 2 and again on day 3. During period 2 a significantly lower percentage of time was spent in safe zones. The time spent in the safe zones increased on day 2 and again on day 3.

The danger zones only became truly dangerous to the piglets when the sow was sitting or standing. Crate type had no effect on the sow's standing behavior. The sows stood up for significantly less time during period 2 which occurred right after farrowing. Piglets spent more time standing and lying in front creeps in the Straight-with creep and Angle-with creep pens as they were the only two pens with front creeps. In the Converta-pens piglets spent significantly more time lying in the Other areas of the pen rather than in the danger or safe zones. These areas are without supplemental heat and may have resulted in chilled, weak piglets which are more susceptible to crushing. The lowest percentage of time spent in the danger zones occurred in the Converta-pens even though the death losses were the highest in this pen. The straight crates with front creeps recorded the highest percentage of time spent by piglets in the danger zones, but this only occurred immediately after farrowing. During successive time periods the straight crates without front creeps had a much higher percentage of time spent in danger zones as compared to the same crate with a front creep. The same trend occurred in the angle crates. Unfortunately, the highest percentage of time was spent in the danger zones when the piglets are too small and not agile enough to escape the sow. Straight-with creep pens recorded significantly more time spent nursing, as a result of the udder being more accessible due to pen design.

Although farrowing pen design is important in reducing death losses, the time period immediately after farrowing is obviously the most critical one for piglets. Piglets prefer to lay by the sow regardless of creep design during the first 24 hours. To help reduce pre-weaning mortality producers may have to observe the sow and litter more frequently post-farrowing and intervene whenever possible.

Technical Report #1, R86-01-0148

# FARROWING CRATE DANGER ZONES

G.I. Christison and J.A. de Gooijer

## ABSTRACT

Modern day farrowing pens can be divided into what are considered "danger" zones and "safe" or creep areas. A relatively large percentage of piglets die in the first few days post-farrowing. The percentage of time piglets spend in these areas and how it affects mortality was studied. The five crate/pen designs were: Straight-no front creep, Straight-with front creep, Converta-pen, Angle-no front creep and Angle-with front creep. Danger zone usage was unaffected by pen design but it was greatly influenced by time since farrowing. Safe area usage showed significant daily increases from day 1 to day 3. Piglets spent significantly more time in the nursing position in the straight-with front creep pens than the others. Careful observation and intervention on the part of the producer during the time period immediately post-farrowing may help reduce pre-weaning mortality.

## BACKGROUND AND OBJECTIVES

With all the developments in modern day farrowing systems a relatively large percentage of newborn piglets die during the first few days post-partum due to starvation and crushing. The farrowing pen can be divided into safe "creep" areas and high risk "danger" zones near the sow where disadvantaged piglets are liable to be crushed. An accurate idea of time allocation in these areas is essential to evaluate potential crushing losses in different pen layouts. Maximizing the amount of time piglets spend in the creep areas should help reduce mortality. What techniques and pen designs can be implemented to increase the time away from the sow?

The objectives of the project were to evaluate the amount of time piglets spend in the "danger zones" and in the creep areas within the first three days after birth and to relate these to piglet mortality.

## EXPERIMENTAL METHODS

Twenty-five purebred sows from the Prairie Swine Center were placed on test. Only sows were used in this trial as gilts' farrowing behavior was too unpredictable. Each of the animals was randomly assigned to one of the pen designs. Five animals were evaluated in each of the 5 farrowing crate/pen designs for sow and piglet behavior and performance. The five pen designs were 1) Straight-no front creep 2) Straight-with front creep 3) Converta-pen 4) Angle-no front creep and 5) Angle-with front creep (Figure 1). All of the crates with the exception of the Converta-pen were KG Johnson. All of the pen floors were plastic-coated expanded metal (Tenderfoot). All pens measured aproximately 1.5 m x 2.47 m including the creep areas.

Floors were marked with a grid outlining six distinct areas, labelled A to F, which were constant in all crates studied (Figure 1). Sectors A,B & C were directly underneath the sow. D and E were the heat lamp areas beside the sow and F was the front creep area regardless of lamp location. This aided observers in determining exact animal numbers and the amount of time spent in each area. Heat lamps were hung aproximately 450 mm from the floor surface. In the straight pens where the front creep was accessible both heat lamps were repositioned from beside the sow to the front creep area 24 hours after farrowing was complete (Figure 1). In the angle pen with front creeps only the lamp from zone D was moved as the sow feeder partially blocked the creep area.

A technician observed the sow and litter during the farrowing process and for several time periods during the following 2 days. All the sows were induced with 2 ml of prostaglandin on day 112 and with 2 ml of oxytocin on day 113. Once sows were farrowing there was a minimum of assistance given to newborn piglets. Personnel only intervened if severe injury or piglet death could be prevented. Time lapse video cameras were also used to monitor creep area utilization on a continuous basis for the first 3 days. Piglets were weighed, dried and numbered on their backs and set back behind the sow once the number was dry. Piglets were also ear notched, castrated, injected and tail docked after the first 4 hour observation period was finished.

Sow and piglet movements and behavior were recorded on a continuous basis during the farrowing process (Period 1). Period 2 lasted for 4 hours after the last piglet born had been numbered and returned to the sow. Periods 3 and 4 occurred in the morning and afternoon on Day 2 and Periods 5 and 6 on Day 3. Periods 3 to 6 were 2.5 hours in length. Data was collected on a daily basis on piglet weight gain, injuries and treatments and as well as mortality. Detailed calculations were done on the percentage of time spent in the various areas from the observation data.

## RESULTS AND DISCUSSION

### General Behavior

Sow and piglet behavior is discussed in relation to crate type and time periods studied. The five crate/pen types are shown in Figure 1. The five layouts were: 1) Straight-no front creep 2) Straight-with front creep 3) Converta-pen 4) Angle-no front creep and 5) Angle-with front creep. ABC denotes the floor area within the crate bars (Figure 1) which will be referred to as the danger zones. D and E refer to the areas adjacent to the sows' udder regardless of heat lamp position and F designates the front creep areas. A heat lamp was moved from zone D to the front creep area when the piglets were 24 hours old. Only two of the five pen types had front creeps. DEF are considered to be safe zones for the piglets. The term Nurse refers to piglets which are either nursing or asleep in the nursing position. Any area of the pen floor which is not included in the zones ABC, DEF or Nurse are referred to as "Other".

Time Period

Piglet behavior was influenced by time period. In this trial there were six observation periods. However, Period 1 (during farrowing) was so variable it was eliminated leaving 5 periods for analysis.

Piglet behavior in the danger zones (ABC) was greatly affected by the time period. Piglets spent significantly more time in ABC during Period 2 than any other time period. In zone D, piglets spent more time standing during Period 3 (morning after farrowing). This may have been an effect of the removal of the heat lamps from zone D to zone F at 24 hours. Piglets spent significantly less time lying in zone D during Period 2 than other areas. This was caused by the piglets lying near the sow's udder instead. The same trend occurred in zone E with piglets spending significantly more time lying during Periods 5 and 6 (Table 1).

In the front creep area (F), during Period 2 piglets spent significantly less time lying than in any of the other time periods because there were no heat lamps. There were significant differences between Periods 3 & 4 and Periods 5 & 6, which translate into daily differences. Piglets spent signifcantly more time standing in Other pen areas during Period 2. This is most likely due to the exploratory stage of the farrowing pen. Nursing behavior was greatly affected by time period. Piglets spent significantly more time during Period 2 nursing or sleeping in the nursing position. The amount of time Nursing decreased on Day 2 and again on Day 3.

In summary, the percentage of time piglets spent in ABC was significantly higher during Period 2 than in any of the other time periods. This was due to the piglets spending the majority of their time nursing and when the sow stood up the piglets moved (fell) into ABC. During the time immediately after farrowing, a significantly lower percentage of time was spent in DEF. The time spent in the safe zones increased on Day 2 and again on Day 3.

Zone Use

The analysis showed that the percentage of time piglets spent in ABC was not affected by pen type but the time since farrowing had significant effects. The percentage of time piglets spent in the "safe zones" DEF, was affected by both pen type and time period (Table 1).

Behaviors were recorded as animals standing or lying in the various zones, however, for ease of discussion many of these have been grouped together. Piglet behavior in zone A and B were unaffected by pen type. Piglets spent significantly more time standing in zone C in the Straight-with creep pens and significantly less time lying in zone D than in the other pens. Piglets spent significantly more time standing and lying in zone E in the Straight-no creep and Converta-pens than in the other crates. Piglets spent more time standing and lying in zone F in the Straight-with creep and Angle-with creep pens as they were the only two pens with front creeps. In the Converta-pens piglets spent significantly more time lying in the Other areas of the pen rather than in the danger or safe zones (Table 1).

Piglets spent significantly more time in the Nursing zone in the Straight

-with creep pens than in any of the other pens. They also spent the greatest percentage of time in ABC in this pen type. This may be due to the fact that they slept so close to the sow rather than moving to the heat lamp areas. The smallest percentage of time spent in the danger zones occurred in the Converta-pens. Piglets spent a significantly lower percentage of time in DEF in the Angle-no creep pens than in the Angle-with creep (38.9% vs 48.6%) over the 3 day trial period.

Danger Zones

The danger zones studied were marked as A,B & C which were located directly under the sow (Figure 1). These zones only became truly dangerous to the piglets when the sow was sitting or standing. The minutes the sow was up (MSU) was highly variable between sows. Although no significant differences were found between crate types the time period did have an effect. The sows stood up for significantly less time in Period 2 (Table 2). This time period occurred right after farrowing so the sows were most likely weakened by the farrowing process.

The amount of time the piglets spent in these areas while the sow was sitting or standing is the most important factor. As Table 3 shows, the percentage of time spent in these areas decreased over time. The straight crates with front creeps recorded the highest percentage of time spent by piglets in the danger zones, but this only occurred immediately after farrowing. During successive time periods the straight crates without front creeps had a much higher percentage of time spent in ABC, as compared to the same crate with a front creep. The same trend occurred in the angle crates. Unfortunately, the highest percentage of time was spent in the danger zones when the piglets are too small and not agile enough to escape the sow. It also happened to be the time when the sow was in a weakened state after farrowing. The proportion of time spent in the danger zones (ABC) has been drastically reduced by the day after birth (Table 3).

Front Creep Use

The amount of time the piglets spent in the front creep area (F) differed between the two pen types which were equipped with front creeps (Table 4). During Day 1, the percentage of animals using the creep area was extremely low due to the amount of time piglets spent nursing or lying near the udder. On days 2 and 3 the differences between the straight and angle crates were statisically significant (Table 4). The straight crates attracted a significantly higher percentage of piglets to the front creeps. This could be attributed to several design problems in the Angle-with creep pen. Due to the position of the sow feeder the group lying space was reduced, only one lamp was moved to the front at 24 hours and piglets access to the front creep was only good from one side (Figure 1).

Piglet Mortality

Of the five pen layouts studied, the death losses to 21 days ranged from a high of 28.0% for the Converta-pens to a low of 6.4% for the Angle-No creep pens. The other three crates had aproximately 12.0% mortality to 21 days

(Table 5). The Converta-pens also had the highest percentage of piglets crushed or starved on Day 1. However, long term studies with many litters (reported elsewhere), showed no differences in survival of the different pen layouts.

## CONCLUSIONS AND IMPACT

Danger zone usage was significantly greater immediately after farrowing regardless of creep design.

The percentage of time piglets spent in the safe zones was significantly lower after farrowing but increased during day 1 and again on day 2 after birth.

Piglets spent significantly more time in the Nursing position in the Straight-with creep pens than in the others.

In the Converta-pens piglets spent significantly more time outside the danger and creep zones of the farrowing pen.

In the two pens equipped with front creeps, the straight crate attracted a significantly higher percentage of pigs to the front creep area than the angle crates during days 2 and 3.

Producers could reduce pre-weaning mortality with careful observation of the sow and litter immediately post-farrowing.

## ACKNOWLEDGMENTS

This research was funded by the Agriculture Development Fund of Saskatchewan Agriculture. The authors would like to acknowledge the technical assistance of Dan Crawford and Jo Olver.

TABLE 1. PERCENTAGE OF TIME SPENT BY PIGLETS IN DANGER ZONES (ABC) OR SAFE ZONES (DEF) OR NURSING

| | | Period 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Straight no creep | ABC | 4.9a | 1.9b | 1.6b | 0.7b | 0.7b |
| | DEF | 18.3c | 42.3b | 48.2b | 67.1a | 66.4a |
| | NURSE | 70.6a | 45.2b | 45.5c | 24.5cd | 22.4d |
| Straight front creep | ABC | 9.4a | 0.4b | 0.8b | 0.3b | 0.9b |
| | DEF | 11.3c | 43.9b | 56.4b | 68.4a | 69.5a |
| | NURSE | 67.9a | 51.5b | 41.6c | 26.6cd | 26.6d |
| Converta-pen | ABC | 2.6a | 1.5b | 0.5b | 1.3b | 0.4b |
| | DEF | 24.1c | 54.3b | 52.5b | 58.2a | 52.5a |
| | NURSE | 56.7a | 37.9b | 32.9c | 27.1cd | 32.1d |
| Angle no creep | ABC | 4.5a | 2.0b | 2.3b | 1.4b | 1.5b |
| | DEF | 14.7c | 48.2b | 40.1b | 52.4a | 51.9a |
| | NURSE | 70.7a | 47.6b | 48.7c | 33.1cd | 38.2d |
| Angle front creep | ABC | 3.4a | 1.7b | 1.1b | 0.6b | 0.5b |
| | DEF | 20.6c | 48.0b | 42.6b | 64.5a | 77.0a |
| | NURSE | 68.8a | 41.9b | 47.5c | 28.6cd | 19.3d |

a-d Means in the same row followed by different letters differ ($P<.05$)

TABLE 2. MINUTES THE SOW WAS STANDING (MSU) DURING 5 TIME PERIODS

| | PERIOD | | | | |
|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 |
| Straight-no creep | 3.5a | 12.2b | 9.4b | 25.0b | 15.8b |
| Straight-front creep | 18.0a | 19.0b | 16.8b | 24.8b | 27.4b |
| Converta-Pen | 12.3a | 12.8b | 13.8b | 18.6b | 13.4b |
| Angle-no creep | 6.5a | 19.0b | 18.4b | 37.6b | 17.4b |
| Angle-front creep | 8.8a | 17.6b | 18.0b | 27.2b | 20.4b |

* Values in the same row followed by different letters differ (P<0.05)

TABLE 3. PERCENTAGE OF TIME PIGLETS SPENT IN DANGER ZONES (ABC) WHILE SOW IS STANDING

| | | Period | | | | |
|---|---|---|---|---|---|---|
| | | 2 | 3 | 4 | 5 | 6 |
| Straight no creep | MSU | 3.5 | 12.2 | 9.4 | 25.0 | 15.8 |
| | % | 21.3 | 10.6 | 18.6 | 2.2 | 1.7 |
| Straight front creep | MSU | 18.0 | 19.0 | 16.8 | 24.8 | 27.4 |
| | % | 37.8 | 0.6 | 3.3 | 0.5 | 3.4 |
| Converta-pen | MSU | 12.3 | 12.8 | 13.8 | 18.6 | 13.4 |
| | % | 30.5 | 2.7 | 8.0 | 7.3 | 2.2 |
| Angle no creep | MSU | 6.5 | 19.0 | 18.4 | 37.6 | 17.4 |
| | % | 33.8 | 10.5 | 10.5 | 3.1 | 3.7 |
| Angle front creep | MSU | 8.8 | 17.6 | 18.0 | 27.2 | 20.4 |
| | % | 25.1 | 8.7 | 2.5 | 1.7 | 1.3 |

MSU = minutes the sow was standing

TABLE 4. PERCENTAGE OF ANIMALS USING THE FRONT CREEP AREA (F)

| Hour+ | Straight front creep | Angle front creep |
|---|---|---|
| 0 - 6 | 0.58a | 0.96a |
| 6 - 12 | 0.15a | 0.74a |
| 12 - 18 | 0.15a | 1.25a |
| 18 - 24 | 8.09a | 5.88a |
| 24 - 30 | 39.76b | 12.07a |
| 30 - 36 | 44.35b | 13.09a |
| 36 - 42 | 49.85b | 16.55a |
| 42 - 48 | 53.33b | 27.88a |
| 48 - 54 | 55.42b | 29.95a |
| 54 - 60 | 52.78b | 25.22a |
| 60 - 66 | 54.92b | 33.02a |

a-b Means in the same row followed by similar letters are not statistically significant ($P<0.05$).

+ Hours since birth of the first pig

TABLE 5. PIGLET MORTALITY TO 21 DAYS

| | Found Alive | # Starve+Crush Day1 | Day2 | Day3 | %Deaths | Alive at 21 Days | % Deaths |
|---|---|---|---|---|---|---|---|
| Straight-no creep | 60 | 1 | 1 | 0 | 3.3 | 54 | 10.0 |
| Straight-front creep | 63 | 2 | 1 | 1 | 6.3 | 54 | 15.0 |
| Converta-pen | 50 | 5 | 1 | 1 | 14.0 | 36 | 28.0 |
| Angle-no creep | 47 | 1 | 0 | 0 | 2.1 | 44 | 6.4 |
| Angle-front creep | 49 | 0 | 1 | 0 | 2.0 | 44 | 10.2 |

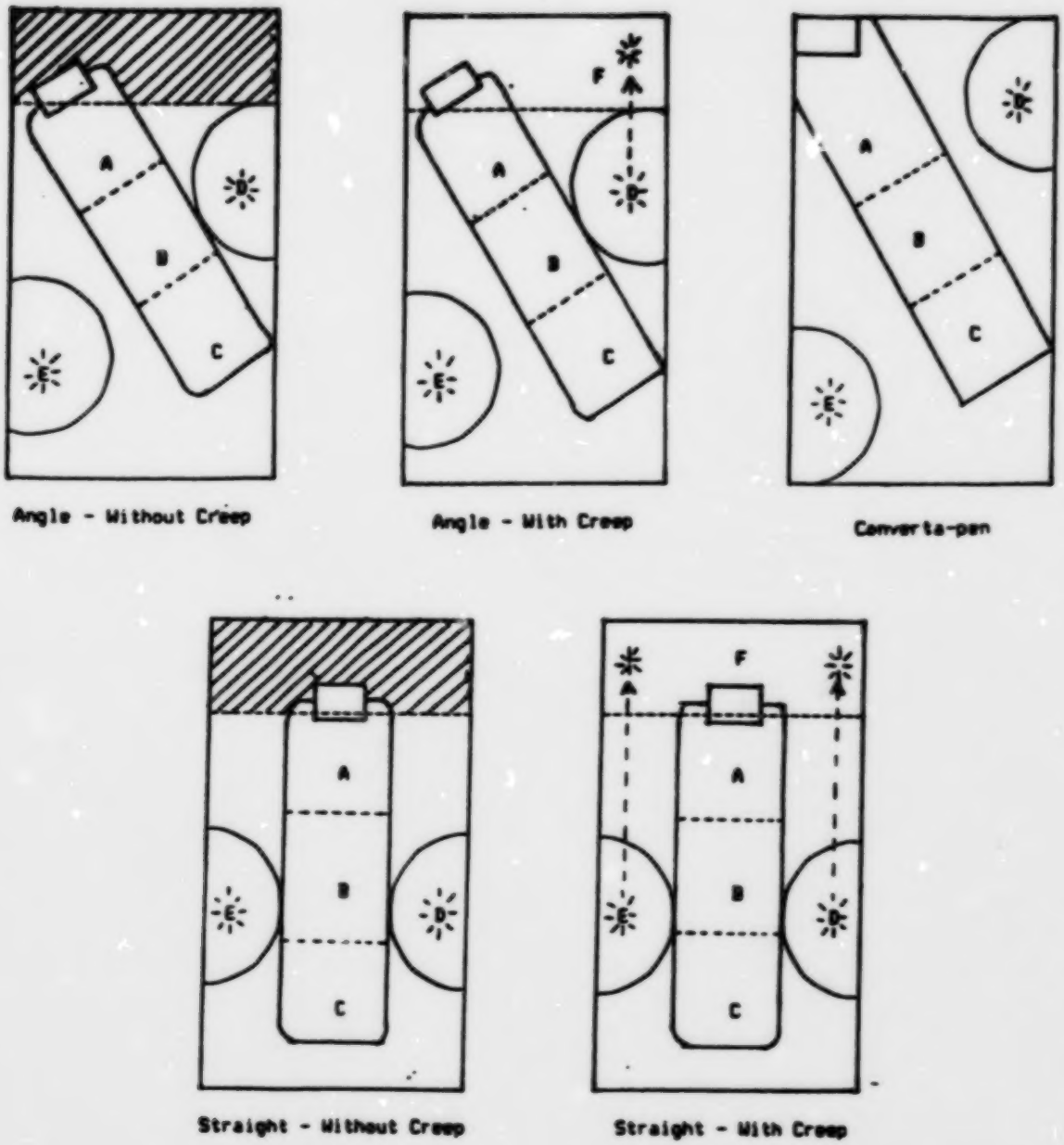



FIGURE 1. Farrowing pen design showing crate orientation, heat lamp position, danger zones (ABC) and safe zones (DEF).

Abstract and Summary #2, R-86-01-0148

# FARROWING CRATES AND FLOORS: THEIR EFFECT ON HEALTH AND PERFORMANCE OF PIGLETS AND SOWS

G.I. Christison and C.S. Rhodes

## ABSTRACT

Design improvements of farrowing crates and flooring materials have resulted in decreased pre-weaning mortality. An evaluation of various crates and floors was conducted at the Prairie Swine Center using herd health data to determine if the crate or floor type had significant effects on the health and performance of sows and piglets. Three crate types were studied: Johnson-straight, Johnson-angle and Converta-pen. Three types of flooring were also tested: Tenderfoot, Cast iron and Tri-bar. Of the three crates tested none showed any effects on animal health or performance. One of the floors (Tri-bar) caused significantly more foot and leg injuries to newborn piglets. This was the primary reason it had been removed from the barn. The other floors performed similarly in respect to the variables studied.

## SUMMARY

Recent improvements in the design of both farrowing crates and flooring materials have led to decreased pre-weaning mortality among newborn piglets. Minimizing death losses is of primary concern to producers so the products used in farrowing rooms must be of good quality. Angle crates were chosen for this trial as they provide a greater "safe" area near the sow's udder. An evaluation of several crates and floors at the Prairie Swine Centre was conducted to determine the effects of crates and floors on the health and performance of piglets and sows.

Herd health data were collected on four years of production in the 50 sow purebred, minimal disease unit and analyzed with respect to animal health and performance variables. Three crate types were studied: Johnson-straight, Johnson-angle and Converta-pen. The first two are the same crate but the orientation in the farrowing pen differed. The three flooring materials included plastic coated expanded metal (Tenderfoot), cast iron (Schonlau Life-time Slats) and Tri-bar. The floors were selected because they were considered the best available. After 2 years the Tri-bar flooring was removed and replaced with Tenderfoot. All crates were raised off the main floor and all pens measured approximately 1.52 x 2.74 m including the creep area.

No significant differences were found among the crate types with regards to piglet survival. Other factors such as animal husbandry may be more important in reducing mortality than crate design. Tenderfoot floors had a slightly higher percentage mortality than the other floors but not enough to be statistically significant. Average daily gains were very similar among the crates and floors. All produced good growth rates and 21 day litter weights of over 60 kg.

The two major causes of pre-weaning death losses are starvation and crushing, with crushing being the more important of the two. There were no significant differences among the crates or floors tested. Angle crates had an insignificantly higher percentage of piglets which died of starvation. One type of crushing found in the angle crates occurred when the sow kicked piglets against the side wall. The larger side creeps in the angle pens were of no additional benefit to newborn piglets.

Of the three floors studied, there were no differences in crushing percentages but there was a statistically significant effect on piglet health. Tri-bar had the highest percentage of piglets exhibiting foot and leg problems due to the abrasiveness of this floor. This was the primary reason it was removed from the barn. Sow health and piglet scours were unaffected by crate design or floor type.

The three crates and floors studied performed similarly when compared on the basis of the variables outlined. Angle crates may hinder piglet movement within the pen. Crushing accounts for the greatest percentage of pre-weaning mortality. Tri-bar floors were significantly worse than the other floors with respect to piglet foot and leg injuries.

Swine producers who implement good management and animal husbandry techniques may.t attain reasonable performance data with many of the crate types and flooring materials on the market.

Technical Report #2, R-86-01-0148

# FARROWING CRATES AND FLOORS: THEIR EFFECT ON HEALTH AND PERFORMANCE OF PIGLETS AND SOWS

G.I. Christison and C.S. Rhodes

## ABSTRACT

Design improvements of farrowing crates and flooring materials have resulted in decreased pre-weaning mortality. An evaluation of various crates and floors was conducted at the Prairie Swine Center using herd health data to determine if the crate or floor type had significant effects on the health and performance of sows and piglets. Three crate types were studied: Johnson-straight, Johnson-angle and Converta-pen. Three types of flooring were also tested: Tenderfoot, Cast iron and Tri-bar. Of the three crates tested none showed any effects on animal health or performance. One of the floors (Tri-bar) caused significantly more foot and leg injuries to newborn piglets. This was the primary reason it had been removed from the barn. The other floors performed similarly in respect to the variables studied.

## BACKGROUND AND OBJECTIVES

Vast improvements in recent years in the design of both farrowing crates and flooring materials have led to decreases in mortality among newborn pigs. However, there still may be differences between the current products on the market with respect to their effects on health and performance. Because minimizing piglet mortality is of primary concern to producers, the crates and flooring used in farrowing rooms should be of high quality. Angle crates were chosen for this trial as they were believed to provide a greater "safe" creep area near the udder. Piglets tend to lie there during the first day post-farrowing regardless of creep design. Evaluation of various crates and floors was conducted at the Prairie Swine Center using health and production data.

The objectives of the project were a) to determine if crate type or flooring material had a significant effect on health and performance of sows and piglets, and b) to determine which effects occurred: changes in mortality, health or average daily gain.

## EXPERIMENTAL METHODS

Health data were collected on four years of production from the 50-sow purebred, minimal disease unit. Crates and floors were in a 3 x 3 factorial layout uniformly distributed in an 18-pen farrowing room. There were three crate types: Johnson-straight, Johnson-angle and Converta-pen (Figure 1). The first two were identical crates but their position in the farrowing pen was different (Figure 2). The angle crates gave a wider lying area for piglets near the sow's udder. The three flooring materials were plastic coated expanded metal (Tenderfoot), cast iron (Schonlau Lifetime Slats) and Tri-bar. After approximately 2 years the Tri-bar flooring was replaced with Tenderfoot

leaving only two floor types for the remainder of the study. All crates were raised 300 mm off the main floor with the back one third of the pen located over the manure pit. All pens measured approximately 1.52 x 2.74 m which included the creep area.

Statistical analyses of the detailed barn records allowed for the comparison of the various crate and floor types with respect to health and animal performance variables.

## RESULTS AND DISCUSSION

Crate type had no effect on animal health or performance. However, there were flooring effects on animal health. It should be noted that the floors selected for this barn were chosen because they were considered the best of the available flooring materials. Although the three crates and floors studied performed similarly, there may still be significant differences between these and other products on the market. Sow and piglet health and performance are described in further detail.

### Piglet Survival

There were no significant differences in the total number of pigs born per litter among the crates or floors used in this study (Table 1). Piglets reported as found dead (Table 1) were not tested to see if they were still-born or had died shortly after birth. Both the Converta-pen and the Tenderfoot flooring had higher numbers of piglets classed as born dead.

Pre-weaning mortality is generally calculated as a percentage of the pigs born alive. However, pigs found dead should be taken into account to give accurate death losses. Tenderfoot floors had a slightly higher percentage mortality than Tri-bar (13.95 vs 11.31%), but these differences were not significant (Table 1).

Converta-pens had the highest pre-weaning mortality and numbers of piglets found dead among the crates tested. There were, however, no significant differences among the three crates (Table 1). Other factors such as good husbandry may be more important in reducing mortality than pen design.

### Piglet Growth

Average birth weights were very similar among the three crate types (Table 2). Average daily gains ranged from 209 g/day in the Angle crates to 218 g for the scraight crates, this resulted in the heaviest 21 day weights also, but none of the differences were statistically significant.

Within the floor types, the cast iron flooring showed the highest average daily gains of 219 g/day and the heaviest 21 day weight of 6.10 kg (Table 2). All of these are good growth rates and produce 21 day litter weights well over 60 kg.

## Causes of Piglet Death

The two major causes of pre-weaning death were starvation and crushing. There were no significant differences among the crates or floors used in this study. Angle crates showed an insignificantly higher percentage of piglets dead from starvation than in the other crates (Table 3). This may be due in part to pen layout (Figure 2). The angle crate's bars almost touch one side wall at the rear (Figure 2) and this, along with the sows back legs, could provide a barrier to the newborn piglet already weakened by the stress of the farrowing process. Unable to reach the udder, these piglets become prime candidates for chilling and starvation. There is potential for the same type of problem to occur in the Converta-pens.

Cast iron flooring had the highest percentage of starved piglets (2.50%) while Tri-bar showed 1.60% (Table 3).

Crushing losses account for the greatest percentage of pre-weaning mortality among the crates studied. Although no significant differences appeared, the Angle and Converta-pens had the highest percentages of crushing (Table 3). One type of crushing found in both these crate designs occurred when the lying sow kicked or crushed the piglets against the side wall with her hind feet in the area where the crate and pen wall touched. The narrow pens performed no better or worse than the wide crates. The larger side creeps in the angle pens were of no benefit to the newborn pigs.

Floor type greatly affected the mobility of the newborn pig. Although there were no significant differences between the three flooring materials, Tenderfoot showed the highest percentage (7.26%) of crushed piglets. Tri-bar recorded the lowest percentage of 4.56 (Table 3). This data agrees with an on farm study conducted several years ago, which showed no benefit to Tenderfoot flooring.

## Piglet Health

Scours and foot and leg problems were the main conditions considered as indicators of piglet health. Foot and leg problems was used a collective name for the total number of pigs with splays, arthritis, lameness, toe injuries and knee abrasions. The flooring produced significant effects (Table 4). A statistically significant percentage of animals exhibited more of these types of problems on the Tri-bar floor (Table 4). The abrasiveness of this flooring and the occasional trapping of piglet toes between the bars proved to be one of the primary reasons why it was removed from the barn. The crates had no effect on the percentage of pigs with foot and leg problems.

The standard treatment for animals with scours was a three day program of antibiotics. If the symptoms continued after the designated treatment period, treatment was repeated. Since all the crates were raised off the floor, scours was not a major problem. The cast iron and tenderfoot floors did have higher percentages of pigs treated than the Tri-bar. This may have been due to general cleanliness.

### Sow Problems

There were very low percentages of sows which exhibited any of the three conditions which were analyzed (Table 5). Neither crate nor floor had any effect on the frequency of animals which were off their feed, had high temperatures or a combination of the two after farrowing.

## CONCLUSIONS AND IMPACT

The three crates and floors used in this study performed similarly when compared on the basis of the variables outlined.

Angle crate designs may have some drawbacks when piglet movement within the crate is considered, despite the wider lying area near the udder.

Crushing losses account for the greatest percentage of pre-weaning mortality.

Plastic-coated expanded metal and the cast iron slats had the same effect on piglet survival rates.

The incidence of scours was not a major problem as all crates were raised off the main floor.

Sow health was generally unaffected by crate type or flooring material.

Tri-bar flooring was significantly worse than the other two floors in respect to piglet feet and leg problems.

Swine producers who implement good management and animal husbandry techniques may attain reasonable performance data with many of the crate types and flooring materials on the market.

## ACKNOWLEDGMENTS

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## DISCLAIMER

Reference to commercial products or trade names is for the convenience of the reader and does not imply an endorsement or the exclusion of others which may be similar.

TABLE 1. PIGLET MORTALITY*

| | Total Born | Found Alive | Found Dead | Alive 21 Days | %Dead /Alive | %Dead /Total |
|---|---|---|---|---|---|---|
| CRATE | | | | | | |
| Straight | 11.46 | 10.91 | 0.55 | 9.21 | 13.98 | 13.38 |
| Angle | 11.66 | 11.03 | 0.63 | 9.22 | 14.34 | 13.40 |
| Converta-pen | 11.34 | 10.51 | 0.83 | 9.05 | 14.98 | 13.92 |
| FLOOR | | | | | | |
| Tenderfoot | 11.77 | 10.89 | 0.88 | 9.18 | 15.12 | 13.95 |
| Cast-iron | 11.10 | 10.67 | 0.43 | 9.18 | 14.38 | 13.78 |
| Tri-bar | 11.31 | 10.94 | 0.37 | 9.04 | 11.51 | 11.31 |

* No significant differences

TABLE 2. PERFORMANCE OF NURSING PIGLETS IN THREE CRATES ON THREE FLOORS*

| | Number of Litters | Birth Wt, kg | Daily Gain, g | 21-Day Wt, kg | Litter Wt, kg |
|---|---|---|---|---|---|
| CRATE | | | | | |
| Straight | 131 | 1.46 | 218 | 6.03 | 65.79 |
| Angle | 130 | 1.48 | 209 | 5.88 | 64.86 |
| Converta-pen | 123 | 1.49 | 213 | 5.95 | 62.53 |
| FLOOR | | | | | |
| Tenderfoot | 207 | 1.48 | 210 | 5.88 | 64.03 |
| Cast-iron | 128 | 1.48 | 219 | 6.10 | 65.09 |
| Tri-bar | 48 | 1.42 | 213 | 5.87 | 64.22 |

* No significant differences

TABLE 3. PRIMARY CAUSES OF PIGLET MORTALITY (% OF PIGLETS BORN ALIVE) IN THREE CRATES AND ON THREE FLOORS*

| | Starvation | Crush | Starvation plus Crush |
|---|---|---|---|
| CRATE | | | |
| Straight | 2.05 | 5.80 | 7.85 |
| Angle | 2.38 | 6.77 | 9.15 |
| Converta-pen | 2.07 | 7.93 | 10.00 |
| FLOOR | | | |
| Tenderfoot | 2.10 | 7.26 | 9.36 |
| Cast Iron | 2.50 | 6.92 | 9.42 |
| Tri-bar | 1.60 | 4.56 | 6.16 |

* No significant differences

TABLE 4. INCIDENCE OF PIGLET PROBLEMS (% OF PIGLETS BORN ALIVE) IN THREE CRATES AND ON THREE FLOORS

| | Scours | Foot & Leg Problems+ |
|---|---|---|
| CRATE | | |
| Straight | 7.00 | 8.81 |
| Angle | 9.84 | 8.51 |
| Converta-pen | 9.34 | 8.79 |
| FLOOR | | |
| Tenderfoot | 8.29 | 6.85b |
| Cast Iron | 11.37 | 8.93b |
| Tri-bar | 3.41 | 16.08a |

a,b Values in the same column followed by different letters differ ($P<.05$)
+ The total of splays, arthritis, lameness, toe injuries and knee abrasions

TABLE 5. INCIDENCE OF SOW PROBLEMS (%) IN THREE CRATE TYPES ON THREE FLOORS*

| | Off Feed | High Temp | Combination |
|---|---|---|---|
| CRATE | | | |
| Straight | 4.6 | 10.7 | 3.8 |
| Angle | 3.1 | 4.6 | 3.1 |
| Converta-pen | 1.6 | 4.9 | 4.1 |
| FLOOR | | | |
| Tenderfoot | 3.9 | 7.2 | 1.0 |
| Cast Iron | 3.1 | 4.7 | 4.7 |
| Tri-bar | 0 | 10.2 | 12.2 |

* No significant differences

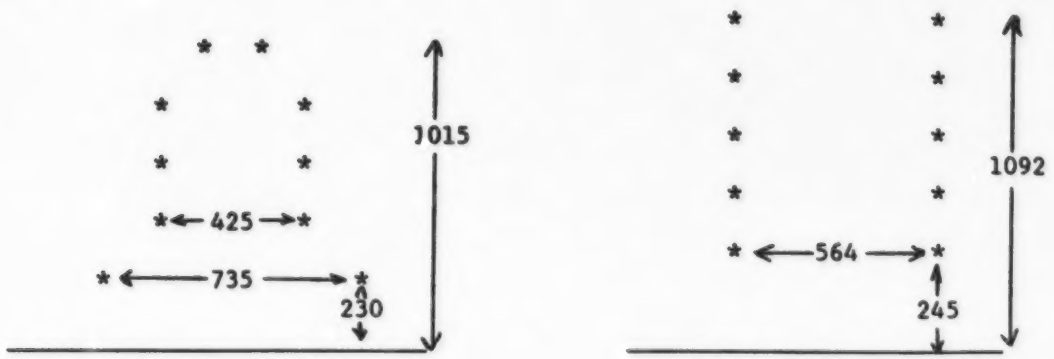


Figure 1. Transverse sections of three farrowing crates showing their dimensions in millimeters.

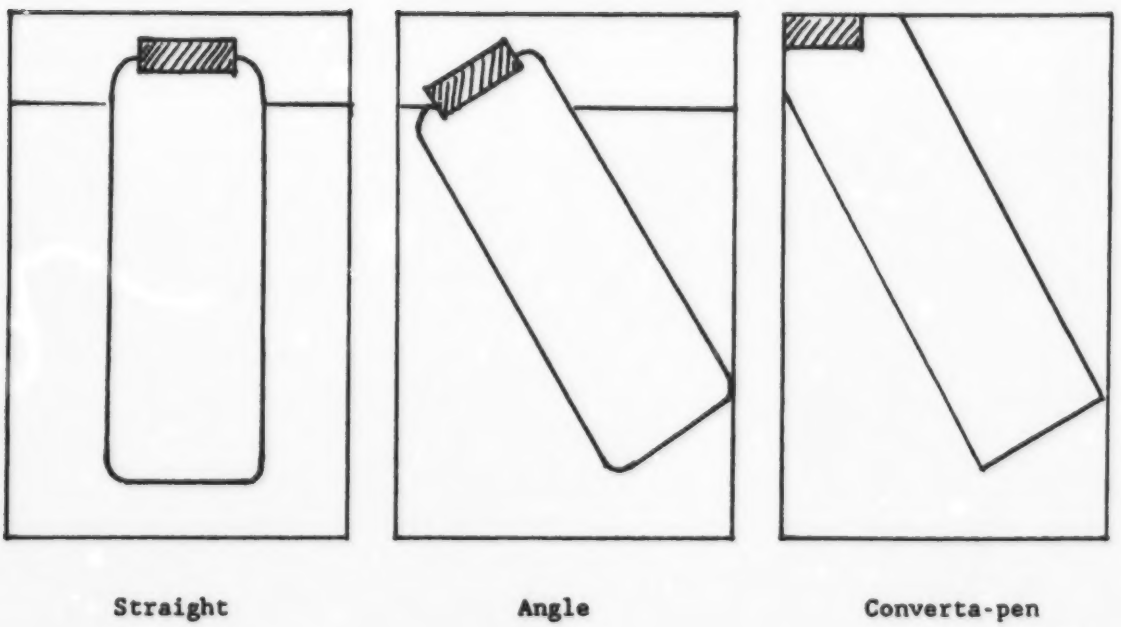


Figure 2. Farrowing pen designs showing crate position (designated by the bottom bar of crate) within the farrowing pen. All pens measured 1.52 meters x 2.74 meters.

Abstract and Summary #3, R-86-01-0148

# EFFECTS OF TUBE-FEEDING WITH A COMMERCIAL MILK REPLACER ON BEHAVIOR AND PERFORMANCE OF NEWBORN PIGLETS

Irene I. Wenger and G.I. Christison

## ABSTRACT

Because there is a problem in the swine industry with lower survival of light birth weight piglets, these studies were undertaken to determine if dosing with a commercial milk replacer solution would improve piglet performance, survival, and ability to tolerate cold, without altering their immunoglobulin status and teat-seeking behavior. In experiments one and two, the single dose of milk improved daily gain and body weight to day 21 when compared with those piglets not receiving milk. No differences were found among treatments in experiment three. The single dose of milk did not improve piglet survival, nor did it alter teat-seeking behavior, immunoglobulin status, or their ability to tolerate cold.

## SUMMARY

The first three days after birth are critical to newborn piglets. If they fail to get a good start early, the pre-weaning mortality may be as high as 20%. Piglets are born with limited energy reserves which are rapidly depleted when they increase their heat production and engage in teat-seeking activities and competition at the udder. Some piglets become irreversibly chilled if they do not gain access to the udder. The colostrum from the sow is very important to newborn piglets. It supplies them with immunoglobulins, which are the first line of defense against disease organisms. As well, colostrum is also a readily available source of supplemental energy. Three trials were performed to determine firstly the effects of tube-feeding two different volumes of milk replacer, and secondly to determine the effects of the time of feeding, on teat-seeking behavior, growth, survival, immunoglobulin status, and the ability of piglets to tolerate the cold. No differences were found among treatments for time to first contact with the udder or time to first suckle in any of the three experiments. Dosing piglets with different volumes of milk replacer (experiment one) resulted in significant improvements in body weight and average daily gain of piglets to 21 days of age. In experiment two, those piglets which were tubed with milk at 2 hours of age also showed significant improvements in body weight and average daily gain to day 21 over those piglets that were sham-fed or tubed at birth. The milk supplementation did not improve piglet performance in experiment three. The overall mortality for experiments one, two and three were 7.1%, 15.4%, and 20.3%, respectively, which are consistent with swine industry averages. Milk supplementation was not found to alter the immunoglobulin status of piglets in experiment two, and it did not reduce the rate of rectal temperature drop of 6-hour-old piglets in experiment three. Although no advantages were seen in piglet performance within the first critical 3 days after birth, this one-time tube-feeding of piglets with a commercial milk replacer resulted in increased weaning weights, and could therefore still have practical applications particularly on farms which have chronic problems with low weaning weights.

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Because there is a problem in the swine industry with lower survival of light birth weight piglets, these studies were undertaken to determine if dosing with a commercial milk replacer solution would improve piglet performance, survival, and ability to tolerate cold, without altering their immunoglobulin status and teat-seeking behavior. In experiments one and two, the single dose of milk improved daily gain and body weight to day 21 when compared with those piglets not receiving milk. No differences were found among treatments in experiment three. The single dose of milk did not improve piglet survival, nor did it alter teat-seeking behavior, immunoglobulin status, or their ability to tolerate cold.

## BACKGROUND AND OBJECTIVES

The first three days after birth are critical to newborn piglets. If they fail to get a good start early, the pre-weaning mortality may be as high as 20%. Piglets are born with limited energy reserves which are rapidly depleted when they increase their heat production and engage in teat-seeking activities and competition at the udder with littermates. Some piglets may become irreversibly chilled if they do not gain access to the udder to suckle. The colostrum from the sow is very important to newborn piglets. It supplies them with immunoglobulins, which are the first line of defense against disease organisms. As well, colostrum is also a readily available source of supplemental energy.

The objectives of this project were a) to determine the effects of tube-feeding two different volumes of milk replacer, and b) to determine the effects of the time of feeding on teat-seeking behavior, growth, survival, immunoglobulin status, and the ability of piglets to tolerate cold.

## EXPERIMENTAL METHODS

### Experiment One

A total of 99 piglets from 11 litters (average birth weight 1409 g) were placed into groups of three, by birth order. Piglets were assigned at random from within these groups to one of three treatments: control (C), low volume (LV) and high volume (HV) of a 25% commercial milk replacer solution (Wet Nurse$^{TM}$, Prairie Microtech Inc., Regina, Saskatchewan). All piglets were dried and tube-fed immediately after birth. Group C was sham-fed and LV and HV piglets were tube-fed at 3.8 or 7.5 mL $kg^{-1}$ body weight, respectively. Time to first contact with the udder, time to first suckle, and growth data were recorded for all piglets.

### Experiment Two

A total of 162 piglets from 18 litters (average birth weight 1403 g) were placed into trios as for experiment one. All piglets were dried at birth, and were assigned at random from within each trio to one of three treatments: control (C), tubed at birth (B), or tubed at 2 h after birth (T). Group C was sham-fed, and B and T piglets were tube-fed 15 mL $kg^{-1}$ body weight. Blood was collected from the anterior vena cava from 136 piglets (from the last 13 litters) at 6 h and 24 h post-partum. The blood was analyzed for immunoglobulin G heavy chains using radial immunodiffusion.

### Experiment Three

A total of 69 piglets from 8 litters (average birth weight 1384 g) were assigned to treatments as for experiment two and the same behavior and performance data were collected. When the youngest piglet in the trio was six-hours-old, the three piglets comprising the trio were fitted with rectal thermocouples and placed in individual crates in a cold chamber (average temperature 4.5°C). Their rectal temperatures were continuously monitored until a decline of 3°C was noted, or one hour had elapsed. Each piglet's rectal temperature decline per hour was then calculated.

## RESULTS AND DISCUSSION

### Teat-seeking Behavior

No differences were found among treatments for time to first contact with the udder or time to first suckle in any of the three experiments (Table 1). Piglets in experiment one appeared to be slower, on average, to contact the udder (12, 6, 10 min., for experiments one, two and three, respectively) and to suckle for the first time (27, 12, 18 min) when compared with piglets in the other two experiments. Piglets in experiment one were only handled for a short period of time immediately post-partum before being returned to the sow, whereas piglets in trials two and three were removed from the sow and held in a heated box for two hours before being returned to the sow. A possible explanation for the quicker times to contact the udder and suckle from a teat is that piglets in trials two and three were thoroughly dried, warmed and rested and appeared to have greater coordination in locomotion than piglets in experiment one. There were, however, great variations within each experiment.

### Growth and Mortality

In experiment one (Table 2) the supplemental milk significantly ($P=0.0315$) improved piglet average daily gain to day 21 (201, 215, 240 g $day^{-1}$ ± 6 SEM for C, LV and HV treatments, respectively), such that piglets on the HV treatment were significantly heavier on day 21 than the piglets on the other two treatments (5605, 5955, 6532 g ± 143, for C, LV, and HV treatments, respectively).

In experiment two (Table 2) the supplemental milk significantly ($P=0.0296$) improved piglet average daily gain to day 21 (221, 227, 230 g $day^{-1}$ ± 4, for

C, B and T treatments, respectively). Piglets which were tubed at 2 hours of age had a significant (P=0.0296) improvement in body weight at 21 days of age, than piglets on the other two treatments (6124, 6166, 6254 g ± 101, for C, B and T treatments, respectively).

Milk supplementation did not improve piglet performance in experiment three.

The overall mortality for experiments one, two and three were 7.1, 15.4, and 20.3%, respectively, which are consistent with swine industry averages.

### Immunoglobulin Status and Cold Tolerance

In trial two, the immunoglobulin status at 6 hours (1897, 1979, and 1970 mg $dL^{-1}$ ± 123) and at 24 hours (4704, 4637, and 4413 mg $dL^{-1}$ ± 143, for treatments C, B and T treatments, respectively) was not affected by the imposed treatments.

In trial three, tube-feeding of milk did not reduce the rate of rectal temperature drop of 6-h-old piglets (5.2, 4.9, 6.4°C $h^{-1}$ ± 0.6, for C, B and T treatments, respectively).

## CONCLUSIONS AND IMPACT

Dosing piglets with different volumes of milk replacer (experiment one) resulted in significant improvements in body weight and average daily gain of piglets to day 21. In experiment two, those piglets which were tubed with milk at 2 hours of age also showed significant improvements in body weight and average daily gain to day 21 over those piglets that were sham-fed or tubed at birth. These improvements in body weight to 21 days is encouraging.

The tube-feeding of milk replacer did not alter teat-seeking behavior, or the immunoglobulin status of the piglets. The similar IgG values obtained from the three imposed treatments indicates that the tube-feeding of milk does not affect the absorption in the piglets' gut of immunoglobulin G from colostrum, and will thus not reduce its protective value to the piglet.

Although no advantages were seen in piglet performance within the first critical 3 days after birth, this one-time tube-feeding of piglets resulted in increased weaning weights, and could therefore still have practical applications particularly on farms which have problems with low weaning weights.

## ACKNOWLEDGMENTS

This project was supported by a grant from the Agriculture Development Fund of Saskatchewan Agriculture. The technical assistance by Valerie Wiemken, Jo-Anne de Gooijer and Carol Elian, as well as the cooperation of the staff of the Prairie Swine Centre is gratefully acknowledged.

Table 1. Effects of different treatments in different experiments on time to first contact with the udder (min) and time to first suckle (min)

| | Experiment 1 | | | Experiment 2 | | | Experiment 3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | C[2] | low | high | C[2] | birth | 2 h | C[2] | birth | 2 h |
| Udder[1] | 11 | 17 | 9 | 3 | 9 | 6 | 10 | 9 | 9 |
| Nurse[1] | 22 | 37 | 22 | 10 | 13 | 12 | 19 | 18 | 15 |

[1] These are adjusted minutes to the udder or first suckle. Minutes while the sow stood were subtracted from the total time to first contact with the udder and first suckle.
[2] Piglets in this group were sham-fed

Table 2. Effects of different treatments, in different experiments, on growth and 6 hour rectal temperatures of neonatal piglets

| | | Birth weight (g) | Temp at 6 h (°C) | ADG to 21 d[1] (g/day) | Day 21 wt (g) |
|---|---|---|---|---|---|
| Expt 1 | none | 1341 | 38.4 | 201b | 5605b |
| | low | 1390 | 38.5 | 215ab | 5955b |
| | high | 1497 | 38.7 | 240a | 6532a |
| Expt 2 | none | 1461 | 38.8 | 221b | 6124b |
| | birth | 1345 | 38.7 | 227ab | 6166ab |
| | 2 h | 1404 | 38.6 | 230a | 6254a |
| Expt 3 | none | 1371 | 39.0 | 211 | 5848 |
| | birth | 1425 | 38.9 | 221 | 6070 |
| | 2 h | 1357 | 38.7 | 202 | 5640 |

[1] Average daily gain to day 21 was adjusted to gain on a 24 hour basis
[a,b] Values in the same column and experiment followed by different letters differ ($P<0.05$)